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*Publication date:*
2018

*Document Version*
Version created as part of publication process; publisher's layout; not normally made publicly available

# Investigation of the usefulness of weather generator data as input to long-term simulations in urban hydrology

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## Abstract

The technical lifetime of urban water infrastructure has a duration where climate change has to be considered when alterations to the system are planned. Also, models for urban water management are reaching a very high complexity level with e.g. decentralized stormwater control measures being included. These systems have to be evaluated under as close-to-real conditions as possible. Long Term Statistics (LTS) modelling with observational data is the most close-to-real solution for present climate conditions, but for future climate conditions artificial rainfall time series from weather generators (WG) have to be used.

In this study we run LTS simulations with four different WG products (namely the ones described in Onof and Arnbjerg (2009), Sørup et al. (2016; 2017) and Thorndahl et al. (2017)) for both present and future conditions on two different small Danish catchments with simple sewer systems and rather frequent Combined Sewer Overflows (CSOs).

The overall objective of this study is to compare and investigate the usefulness of various rainfall generators for LTS simulations and furthermore investigate how much the choice of rainfall generator affects the LTS results under the influence of climate change. The study focuses on indicators representing either aggregated statistics (e.g. Total CSO volumes) or the non-linear responses of the sewer system (e.g. number of full flowing pipes).

For present conditions, the rainfall from all WGs behave much like the observations for moderate extremes relevant for the investigated indicators (see Figure 1), and for climate change the change is evident for all WGs.

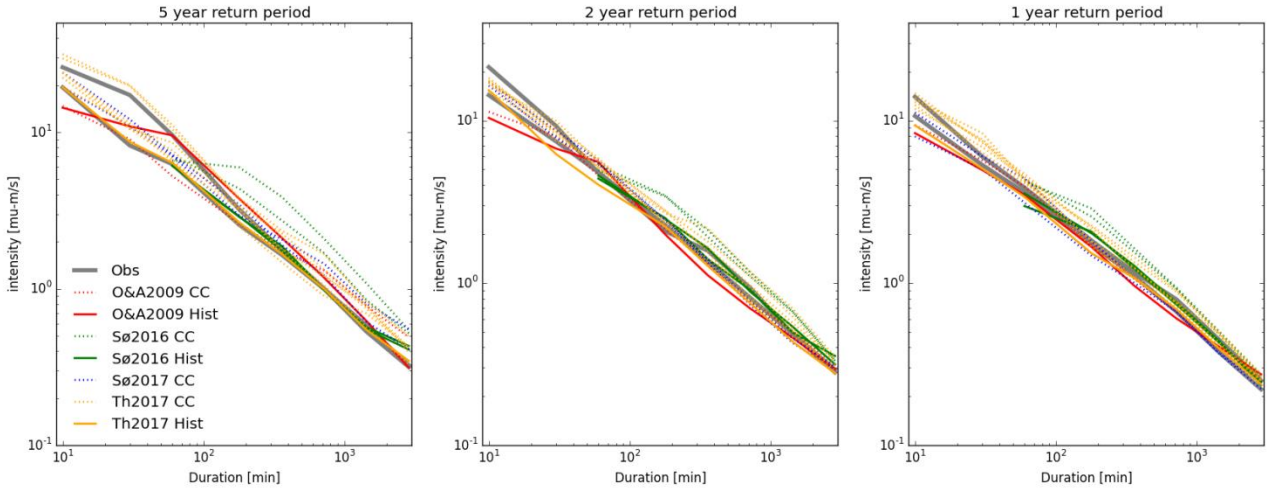

Fig 1: IDF relationships for observations and WGs for present (Hist) and future (CC) climate. For present conditions all WG products result in realistic catchment responses when it comes to the number of full flowing pipes and the number and volume of CSOs. For future conditions, the differences in the WGs representation of the expectations to climate change is evident. Nonetheless, all future results indicate that the catchments will have to handle more events that utilize the full capacity of the drainage systems. Generally, WG products seem relevant to use in planning of future changes to sewer systems.

The results of this study show that artificial rainfall data from weather generators can be useful as inputs for LTS simulations as the different methodologies all produce time series that are sufficiently similar to observed rainfall to generate a realistic response in the drainage network. No weather generator product clearly outperforms the others (see Table 1), but high temporal resolutions and geographical representativeness are important parameters to consider for smaller catchments.

Tab 1: Relative qualitative performance of each of the indicators and each of the weather generator used for present climate, rated between perfectly within uncertainty of calculation (+++++) and definitely outside uncertainty of calculation (+). Modified from Sørup et al. (2018).

| | ***Onof and Arnbjerg (2009)*** | ***Sørup et al. (2016)*** | ***Sørup et al. (2017)*** | ***Thorndahl et al. (2017)*** |
|---|---|---|---|---|
| Application for small catchments (where point rainfall is appropriate) | ++ | + | ++++ | ++++ |
| Seasonal statistics | +++ | ++ | (+++) | ++++ |
| Estimation of full flowing pipes (small catchments) | +++ | + | ++++ | ++++ |
| CSO frequency | ++++ | ++++ | ++++ | ++++ |
| CSO volume | ++++ | ++++ | ++++ | ++++ |
| Flexibility in inclusion of climate change (as in how easy it is to get hold of relevant data for perturbation) | +++ | + | +++++ | +++ |

The full study has been published in Water Science and Technology as Sørup et al. (2018): doi: 10.2166/wst.2018.217.

**References**

Onof, C. and Arnbjerg-Nielsen, K. (2009). Quantification of anticipated future changes in high resolution design rainfall for urban areas. *Atmospheric Research*, 92(3), 350–363. doi:10.1016/j.atmosres.2009.01.014.

Sørup, H. J. D., Christensen, O. B., Arnbjerg-Nielsen, K., and Mikkelsen, P. S. (2016). Downscaling future precipitation extremes to urban hydrology scales using a spatio-temporal Neyman–Scott weather generator. *Hydrology and Earth System Sciences*, 20(4), 1387–1403. doi:10.5194/hess-20-1387-2016.

Sørup, H. J. D., Davidsen, S., Löwe, R., Thorndahl, S. L., Borup, M., & Arnbjerg-Nielsen, K. (2018). Evaluating catchment response to artificial rainfall from four weather generators for present and future climate. *Water Science and Technology*, wst2018217. doi:10.2166/wst.2018.217.

Sørup, H. J. D., Georgiadis, S., Gregersen, I. B., and Arnbjerg-Nielsen, K. (2017). Formulating and testing a method for perturbing precipitation time series to reflect anticipated climatic changes, *Hydrology and Earth System Sciences*, 21, 345-355, doi: 10.5194/hess-21-345-2017.

Thorndahl, S., Andersen, A. K., and Larsen, A. B. (2017) Event-based stochastic point rainfall resampling for statistical replication and climate projection of historical rainfall series, *Hydrology and Earth System Sciences*, 21, 4433-4448, doi:10.5194/hess-21-4433-2017.